



White Paper

Energy Recovery: Importance, Initiatives, and Involvement

Expanding the Potential for Plastic Packaging

Dow's Performance Packaging business has the largest packaging franchise of any global materials supplier. Dow's broad portfolio of resins and films offer machine manufacturers, converters, brand owners, retailers, and consumers advantaged options to help improve operational efficiencies, economics, functional performance, aesthetics, convenience, and sustainability across a variety of high value packaging market segments.

Energy recovery helps divert used plastic packaging from landfills and converts it into a valued source of fuel or feedstock. This approach can create an alternative energy source for use in manufacturing operations, reducing the dependence on fossil fuels, natural gas and oil.

options such as metal, glass or paper, the use of plastics can often help reduce the weight of materials needed for packaging, decrease fossil fuel consumption, and lower energy use for transportation or refrigeration of packaged products¹.

The use of plastics in packaging helps leading retailers and brand owners differentiate their brands and achieve advantages with logistics management and sustainability. With leading-edge polymer science, "best-in-class" process technology, a proven record of innovation, and a corporate commitment to sustainability, Dow is working actively with the entire value chain to further expand the potential for plastics. In the performance packaging segments it serves, Dow focuses on helping customers improve the sustainability profile of their packages through increased functionality, reduced resource consumption, and improved overall lifecycle performance.

Successful strategies to expand the potential for plastic packaging must now proactively address end-of-life options as an important part of the overall product lifecycle. Packaging that has already been used, reused, or mechanically recycled to the full extent possible is often viewed as waste that fills up landfills, and these negative misperceptions can limit the prospects for growth. Disposal in landfills, however, may not always be the best or only answer. In fact, in areas such as Europe, zero-to-waste

approaches are helping to divert most waste from landfills. Even after it has served its original purpose and is at its end of life, used plastic packaging is a resource that can be recovered, diverted from landfills, and turned into an alternate form of energy that is "too valuable to waste."

A "Best-in-Class" Approach

Energy Recovery is the practice of recovering the embedded energy in used materials such as plastic packaging. Processes such as combustion and chemical transformation can help capture the full value of end-of-life plastics. Dow's Performance Plastics business supports energy recovery as a "best-in-class" approach and strategy that can provide additional end-of-life options, divert used plastics from landfills, and help move the industry toward the vision of "100% Recycling of Packaging." In manufacturing operations, energy recovery can create a valuable alternative energy source, reducing dependence on natural gas, oil, and coal. Recent initiatives proved the value of using energy recovery methods in Dow manufacturing operations, and efforts are underway to broaden its use industry-wide.

Energy recovery efforts extend the industry's commitment to further improve the sustainability profile of plastic packaging. Diverting used plastics from landfills builds positive perceptions and preferences across the value chain for the use of these high performance packaging products.

Dow is actively working to:

- increase awareness of the importance of energy recovery throughout the value chain
- undertake initiatives that will prove the value of this end-of-life approach
- play a thought leadership role in building industry interest, advocacy, and involvement

Generating Added Energy Value

Energy recovery is a resource management method that takes end-of-life plastics through a conversion process and uses the resulting energy value as a fuel. The combustion method of energy recovery is also known as thermal recycling, and is referred to as "recycle-to-energy" (RTE) within Dow. Thermal recycling is the most common method for recovering the energy from used plastics in North America. Energy recovery programs can generate added value from used primary packaging (consumer goods), used secondary packaging (e.g., non-recycled stretch and shrink film), and industrial scrap. Polyethylene, polypropylene, and polystyrene in particular have high material energy values – greater than coal and almost as high as heating oil – and are especially valuable sources of recovered energy.²

Successful strategies to expand the potential of plastic packaging must now proactively address end-of-life (EOL) options.

Positive Sustainability Profile

Energy recovery programs divert plastics from landfills and result in using those materials to generate an added source of energy. The overall sustainability profile of energy recovery is positive³. The U.S. Environmental Protection Agency (EPA) recognizes energy recovery as an advantageous end-of-life approach, stating that it is a “clean, reliable, renewable source of energy” with a lower total environmental impact than most other energy sources.

When plastics are thermally recycled at the right temperature and conditions, energy recovery approaches fall well within regulatory limits⁴. Thermal recycling enables the maximum utility capture from every natural gas or oil molecule used as a feedstock to make plastics, as these plastics can be used, reused, recycled, and recovered to recapture the full energy value of the original feedstock.

100% Recycling of Packaging

The first option for recovery of many plastics is mechanical recycling. While mechanical recycling is a major part of the solution, it alone can’t meet landfill diversion goals in an economically feasible manner. Mechanical recycling is primarily intended for larger volume treatment of mono-materials (typically PET and HDPE bottles), and has limitations in terms of technology, logistics, costs, and infrastructure.

The goal to increase the overall recovery of plastics and other materials requires broader integration of mechanical recycling with chemical transformation and energy recovery. Ultimately, the intent is to use different recovery methods in a complementary manner so that “100% Recycling of Packaging” can be achieved across the globe, whether the recovery process used is mechanical recycling, composting, chemical transformation, or energy recovery.

The ideal equation the plastics industry is working toward is:

$$\begin{array}{l} \text{Mechanical Recycling} \\ + \text{ Composting} \\ + \text{ Chemical Transformation} \\ + \text{ Energy Recovery} \\ \hline 100\% \text{ Recycling of Packaging} \end{array}$$

Adopting “100% Recycling of Packaging” programs will help the industry advance from the 3R mindset of “Reduce, Reuse, Recycle” now widely practiced in North America to the more comprehensive efforts being used in regions such as Europe that add the 4th R for end-of-life materials – “Reduce, Reuse, Recycle, **Recover**.” Using an integrated 4R approach will help assure greater total value recovery from end-of-life plastics and other used materials.

Advancing the Adoption of Energy Recovery

The vision of “100% Recycling of Packaging” follows the viewpoint that end-of-life plastics and other used materials have value and should be recovered and converted into alternate usable forms instead of being disposed of in landfills. For plastics that cannot be mechanically recycled, such as multi-material complex structures, energy recovery is a viable way to recover the embedded energy or feedstock value. In certain parts of Europe, collection systems and treatment technologies for plastics are

well established and enable the integration of mechanical recycling with energy recovery. Due to an effective collection and recovery infrastructure in many areas of Europe, consumer participation is broad, overall recovery rates are very high, greater amounts of energy are recovered, and more materials are diverted from landfills. When recycling and energy recovery are efficient and economical options for used plastics, consumers and others in the value chain increasingly view end-of-life plastics as a resource that is too valuable to waste.”

In North America and other regions where energy recovery is not yet widely adopted, a more effective system is needed to collect and treat used plastics for mechanical recycling and energy recovery. This 4R approach will help move North America toward the goal of “100% Recycling of Packaging.” Improving the infrastructure and operational options for energy recovery of plastics will help increase collection and create greater value from these integrated efforts. Dow is committed to working with its value chain partners to implement longer-term plans for improved collection, separation, and treatment of used plastics. As regions in the earlier stages of plastics recycling and energy recovery continue to increase implementation rates, the perception of plastics will improve, and its potential for continued global growth will increase.

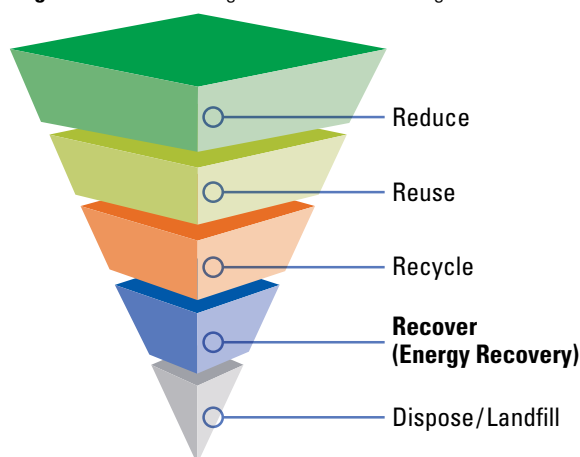
Integrated Resource Management

The philosophy behind resource management is to view materials such as used packaging as a valuable resource and not misperceive it as waste that is worthless. In this way, adopting a resource management approach for used plastics is a more progressive plan for plastics than landfill disposal or mechanical recycling alone.

The opinion of the U.S. EPA is that a collective approach including resource conservation and recovery is needed to handle the nation’s needs. This viewpoint aligns with the vision of a “100% Recycling of Packaging” approach.

The EPA’s resource management hierarchy in Figure 1 illustrates how all resource management options should be integrated to minimize material disposal in landfills. The goal is to handle each element of the used material stream in the most effective, economical, safe, and sustainable manner as practical. Energy **Recovery** is incorporated into the hierarchy below as the fourth “R” – “Reduce, Reuse, Recycle, **Recover**.”

Figure 1: U.S. EPA Integrated Resource Management Hierarchy⁵



³ U.S. Environmental Protection Agency

⁴ Waste To Energy Research and Technology Council, Columbia University, New York

⁵ U.S. Environmental Protection Agency

Complementary Methods to Reclaim Value from Used Packaging

The American Chemistry Council (ACC) supports an integrated approach to achieve the goal of diverting plastics from landfills. The intent is to move toward a complementary “closed loop” system that fully integrates mechanical recycling with energy recovery options. Both mechanical recycling and energy recovery help reclaim the value embedded in used packaging, whether it is gained as a material or energy benefit.

1st Step – Mechanical Recycling

Used plastics should be mechanically recycled whenever economically and environmentally possible. During the mechanical recycling process, materials are separated, cleaned, ground, and reprocessed into recycled pellets for use to make other products containing this recycled content.

2nd Step – Energy Recovery

When mechanical recycling is not practical or possible, remaining materials should be sent to a facility where chemical transformation or energy recovery methods can be used to convert the non-recyclable items into electricity, steam, heat, fuel (diesel, oil, etc.), or chemical feedstocks.

Dow supports the efforts of numerous industry associations such as the ACC Plastics Energy Recovery Team, the Canadian Plastics Industry Association (CPIA) and the Flexible Packaging Association (FPA) Sustainability Task Force. These groups are actively promoting energy recovery initiatives and are conducting trials to demonstrate the potential for various energy recovery and chemical transformation technologies to convert used plastic packaging into a valued alternative source of fuel or feedstock.

Increasing Industry Involvement

Building support for energy recovery requires increasing industry awareness and advocacy and proving the feasibility and value of recycle-to-energy initiatives. As Dow and others in the industry work to build the understanding of energy recovery and increase the participation in programs, the primary objectives are:

Short term:

- Build understanding that end-of-life plastics are a valuable resource
- Increase the industry’s adoption of energy recovery; recover end-of-life plastics on a broader basis; convert used plastics into a valued source of energy

Longer term:

- Increase the use of end-of-life plastics as a valued alternative energy source within manufacturing operations
- Reduce the reliance on using natural gas, oil, and coal for energy or feedstock value

The strategy for increasing industry-wide engagement and scaling up involves:

- Demonstrating and documenting that energy recovery creates value from end-of-life plastics, and complements mechanical recycling

- Providing an easier method for consumer recycling and recovery, including the collection of all used packaging
- Developing the infrastructure to manage “100% Recycling of Packaging” initiatives

Proving the Energy Potential of Used Plastic

In 2010, Dow conducted an energy recovery trial in North America that successfully demonstrated that used plastic can generate energy. The pilot test, conducted at a rotary kiln in Dow’s Michigan Operations, found that 96 percent of available energy was recovered after 578 pounds of used linear low density polyethylene was thermally recycled. The energy recovered was equivalent to 11.1 million BTUs of natural gas and was used as fuel for Dow’s incinerator during the test. The study proved that almost all of the energy embedded in used plastics can be recovered and reused as energy versus being disposed of in a landfill.

In 2011, six additional energy recovery trials were conducted using non-recycled plastics (NRPs) from Dow Michigan Operations to displace natural gas. These trials used 100 tons of NRPs and saved 2 billion BTUs of energy.

The ACC and FPA are also actively working to validate the energy recovery prospects for plastics. Both organizations are investing in energy recovery trials. Information about energy recovery is outlined on the ACC website at <http://www.americanchemistry.com>. The FPA commissioned the Earth Engineering Center (EEC) of Columbia University to conduct a study on the economic and environmental costs and benefits of different options. The findings were released to members in October, 2011, and are detailed in “*Identification and Assessment of Available Technologies for Materials and Energy Recovery from Flexible Packaging Waste Report*.”

Developing the Infrastructure

Implementing “100% Recycling of Packaging” initiatives will require broad collaboration across the value chain, which includes municipalities, Material Recovery Facilities (MRFs), waste haulers, local government authorities, and others. MRFs play a key role in managing materials that cannot be mechanically recycled easily and in increasing the amount of used plastics that go to energy recovery facilities versus landfills. As a result, it will be especially important that MRFs actively engage in integrated energy recovery efforts. Currently, programs are in place where cement kilns and paper plants take residual materials from MRFs and turn them into useful energy⁶. The plastics industry is now developing the infrastructure for energy recovery to be practiced on a broader basis.

Commitment to Energy Recovery

Dow is committed to working with value chain partners, industry associations, and other influencers in the field to increase the viability and use of integrated end-of-life options. The focus of these efforts is on mechanical recycling, chemical transformation, and energy recovery. Many key value chain participants share the commitment to increase end-of-life options for plastic packaging and are investing in efforts to make the common goal of “100% Recycling of Packaging” possible.

⁶ <http://www.plasticseurope.org>

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